SYSTEMS AND METHODS FOR CONTROLLING DEVICE OPERATION ACCORDING TO HAND GESTURES

RELATED APPLICATIONS

[0001] This application is a continuation application of U.S. patent application Ser. No. 14/318,019, filed on Jun. 27, 2014, which claims the benefit of U.S. Provisional Patent Application No. 61/840,791 filed Jun. 28, 2013, the content of which is incorporated herein by reference in its entirety. This application is related to U.S. patent application Ser. No. 13/826,177 filed on Mar. 14, 2013, U.S. Provisional Patent Application No. 61/643,535 filed on May 7, 2012, U.S. Provisional Patent Application No. 61/684,336 filed on Aug. 17, 2012, U.S. Provisional Patent Application No. 61/760,966 filed on Feb. 5, 2013, PCT Patent Application No. PCT/US13/39666 filed May 6, 2013, U.S. Provisional Patent Application No. 61/696,518 filed on Sep. 4, 2012, U.S. Provisional Patent Application No. 61/846,738 filed on Jul. 16, 2013, U.S. patent application Ser. No. 14/048,505 filed on Oct. 8, 2013, U.S. Provisional Patent Application No. 61/985,762 filed on Apr. 29, 2014, the content of each of which is incorporated herein by reference in its entirety.

TECHNICAL FIELD

[0002] The present inventive concepts generally relate to device control, and more particularly relate to devices, systems, and methods for controlling a machine, instrument, robot, vehicle, or other device or object according to hand gestures.

BACKGROUND

[0003] Operation of a machine by a human operator can be summarized as follows. First, an operator can observe or inspect the result of a previous operation. If the desired result is not yet obtained, the operation can continue, or adjustments can be made to the inputs of the next operation. This process can continue until a desired result is obtained.

[0004] Conventional approaches require an operator to control an operation of a machine, device, and/or instrument by way of mechanical elements in communication with the machine, device, and/or instrument, such as a joystick, steering wheel, or foot pedestal.

SUMMARY

[0005] In one aspect, provided is a non-contact sensing device, comprising a sensor comprising a plurality of function key sensors. A function key sensor of the plurality of function key sensors has a field of view. The function key sensor is constructed and arranged to detect a hand gesture at the field of view and to generate a function key control signal in response to detecting the hand gesture at the field of view. A processor processes the function key control signal from the function key sensor and outputs a command to a remote apparatus in response to the processed control signal.

[0006] In some embodiments, the non-contact sensing device comprises one or more cameras that recognize the hand gesture, wherein the command is generated from a combination of a function key corresponding to the function key sensor and the recognized hand gesture.

[0007] In some embodiments, the sensor is a staring sensor comprising a detector array that includes a combination of the function key sensors and non-function key sensors, the staring sensor generating all image pixels of the detector array simultaneously.

[0008] In some embodiments, the sensor is a scanning sensor that scans a portion of a field of view at a time.

[0009] In some embodiments, the sensor includes a scan mirror that scans all function key sensors and only the non-function key sensors in the path of the scan to shorten the data acquisition time.

[0010] In some embodiments, the sensor is constructed and arranged as an emissive mode sensor comprising a thermal sensor that collects thermal radiation emitted from the hand gesture.

[0011] In some embodiments, the sensor is constructed and arranged as a reflective mode sensor comprising a color sensor that collects color light reflected from the hand gesture.

[0012] In some embodiments, the non-contact sensing device further comprises a control spot generator that generates a control spot that is aligned with the field of view, and the function key sensor detects a target within the control spot

[0013] In some embodiments, the sensor detects the hand gesture at the control spot.

[0014] In some embodiments, the non-contact sensing device further comprises a beamsplitter positioned between the sensor and the control spot generator, wherein light output from the control spot generator directed at the beamsplitter coincides with the field of view.

[0015] In some embodiments, a function key corresponding to the function key sensor distinguished from other function key sensors is identified by positioning a ground truth target such as a hand at the control spot among a plurality of control spots and collecting by the non-contact sensing device an image of the ground truth target, wherein a pixel or group of pixels at the sensor having a highest detector output is identified as the function key.

[0016] In some embodiments, the control spot generator comprises a white light emitting diode (LED), a control spot generator plate having a plurality of color filters, and a lens, wherein color light is generated from the color filters when the white LED illuminates, and wherein a plurality of control spots are generated.

[0017] In some embodiments, each color control spot is aligned with a field of view of a function key sensor.

[0018] In some embodiments, the control spot generator comprises a plurality of color LEDs, light pipes, a light pipe mounting plate, and a lens, wherein the color LEDs are placed at the input ends of light pipes and the output ends of light pipes are placed at the focal plane of the lens, thereby generating control spots of different colors that each illuminate a field of view of a different function key sensor, and wherein the light pipe plate holds the light pipes together at the focal plane of the lens.

[0019] In some embodiments, the remote apparatus comprises a plurality of devices, and the processor generates a device number for a device of the plurality of devices, each device number corresponding to a hand gesture at a designated control spot, thereby allowing a user to choose what device to operate.

[0020] In some embodiments, a function key corresponding to the function key pixel become inactive when the hand